Synthesis and Characterisation of VO_2-based Thermochromic Thin films for Energy Efficient Windows

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Abstract

Within the field of "smart" materials, thermochromic coatings are demonstrating a high potential to be applied as energy effective building and automotive window coatings due to their self-adaptative optical properties which actively modulate the solar radiation. Vanadium dioxide is the most promising candidate for this application since it reversively changes its transmission/reflection in the infra-red wavelength range near room temperature, 68ºC.

Solar control coatings are a technology with growing interest due to the necessity of improving the energy efficiency of buildings avoiding excessive energy consumption with cooling systems on summer. The latest approach is based on the use of thermochromic coatings on so-called "smart" windows. These coatings possess the ability of actively changing their optical properties as a consequence of a reversible structural transformation when going through a critical temperature.

Vanadium dioxide is an example of a thermochromic material which is a promising candidate for this kind of application. The change on its optical and also electrical properties takes place at approximately 68ºC as a result of a first-order structural transition, going from a monoclinic to a tetragonal phase on heating. The low temperature semiconducting phase which is transparent to radiation in the visible and infrared spectral ranges maximizes the heating due to blackbody radiation, while the metallic high temperature phase filters the infrared radiation and maintains at the same time the transparency required, in the visible range, to keep an environment of natural

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light. A transition temperature of 68ºC is too high for this application and must therefore be reduced. At present, there are two approaches to reduce the transition temperature, the substitution of part of the vanadium cations by other metals such as tungsten, molybdenum or niobium, or the substitution of part of the oxygen anions by other elements, e.g. fluorine.

In this study, magnetron sputtered VO_2 thin films have been prepared with different doping elements such as W, Mo and Nb and different doping concentrations. We report on the influence of each element and respective concentrations on the crystal structure of the films, optical/thermochromic performance, electrical resistance, surface morphology, and effectiveness on the reduction of the semiconductor-metal transition from 68ºC to room temperature, envisaging the application on energy efficient windows.